Canopy survey of a restored bottomland hardwood forest on the Olentangy River in central Ohio

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Abstract

A vegetation survey of the canopy species was conducted in the bottomland hardwood forest at the Olentangy River Wetland Research Park (ORWRP). The forest runs between the Olentangy River and the adjacent created wetlands within the ORWRP. Currently a levee inhibits natural flow of floodwater from the river. However, restoration efforts were conducted in 2000 by introducing perforations in the levee wall to increase water flow into the forest. This study may provide opportunities for comparison of data regarding the effects of restoration. The point quarter method was used to sample the tree species within the forest. Elevation of each tree was recorded and tree status was found to be relatively consistent throughout. Sixteen tree species were recorded overall, and eight to ten species were recorded per transect. Diameters at breast height (DBH), relative densities and mean distances were calculated to determine the characteristics of the forest population. DBH calculations showed 70% of the trees sampled were between 10-29 cm. Tree species with the highest relative densities were Box Elder (*Acer negundo*) 19%, Ohio Buckeye (*Aesculus glabra*) 18% and Eastern Cottonwood (*Populus deltoides*) 14%. Importance values recorded the same order or species. Mean distance for all transects was 4.75 m. Wetland status of the forest was evaluated according to vegetation and found no significance evidence of wetland conditions.

Introduction

A bottomland hardwood forest is distinguished as a riparian ecosystem located in the eastern United States dominated by deciduous hardwood tree species. It borders a higher order river system that usually is flooded intermittently due to river fluctuations and is the transition zone between the river and the adjacent upland. The forest surface is considered a nutrient sink for upland runoff, but a nutrient transformer for upstream and downstream flows. Riparian ecosystems process large fluxes of energy and material from upstream systems, but are sensitive to climatic and geologic conditions. Flooding of the riparian zone affects soil chemistry by producing anaerobic conditions, importing and exporting organic matter and replenishing mineral nutrients. Periodic pulsing of the river system into the riparian zone can cause an increase in productivity due to the exchange of nutrients and waste without the stressful conditions of continuous flooding. Another benefit of periodic pulsing is the positive impact on seed germination (Mitsch and Gosselink, 2000). The intensity and duration of flooding can also directly affect the growth and mortality of tree species (Dudek et al., 1996). Wetland plants are hydrophilic and have physiological adaptations that allow it to survive high inundation periods. Non-wetland plants are not adapted for saturated soils and they will struggle and possibly die due to the anaerobic conditions (Mitsch and Gosselink, 2000). A bottomland hardwood forest may be considered a wetland if it is dominated by tree species adapted for the anaerobic environment. However, it is necessary to test for soil and hydrologic conditions to fully understand the extent of the wetland environment. Bottomland forests can be difficult to assess for wetland status due to the variability in surface elevation.

The bottomland forest at the ORWRP in Columbus, Ohio, borders the Olentangy River. A levee was built along the river edge over a century ago to reduce the effects of flooding along the riparian zone. Flood events have been drastically altered by the levee, and compounded by the building of dams along the river system. Dammed rivers regulate river flows in such a way that reduces water levels. Flooding events that would normally inundate flood plains become rare. Only under extraordinary flood conditions would a floodplain be covered. Therefore many riparian ecosystems are reduced in size and productivity is compromised (Micucci, 1999).

Over time the levee has deteriorated slightly and some river flow has entered the bottomland forest. In the year 2000, restoration efforts took place to alleviate the impact of the levee. Four perforations were created in the levee to lower the levee and allow more inundation during slightly higher levels of the river. The projected number of yearly flooding events should remain similar, five to eight per year, but water from slightly higher stream flow will now be able to enter the forest surface. Even though river flow may enter more often, water will be removed from the system more quickly and readily than before the levee was disrupted (Acton et al., 1998). The restoration goal is to return the riparian ecosystem to normal flooding patterns, which should increase productivity (Acton et al., 1998).

By opening the levee, a new flood disturbance has occurred in the bottomland hardwood forest. Most forests are subjected to a variety of disturbances; therefore understanding the interactions between them can help us understand the recovery dynamics of the system (Everham and Brokaw, 1996). Flood induced disturbances may change the stable state for the riparian ecosystem. Long-term alterations could create a long-term transition state within the riparian zone (Pettit and Froend, 2001). A higher frequency of flooding could create higher mortality among tree species that are intolerant to anaerobic conditions. Root systems may become weaker and more susceptible to blow down during soil saturation, producing gaps in the forest. Disturbances that partly open the canopy promote further disturbance from the wind (Everham and Brokaw, 1996). Larger gaps mean possible damage to trees that were otherwise secure during high wind events. In hardwood forests where more uprooting has occurred under wetter conditions during increases in wind velocity (Everham and Brokaw, 1996). Also, trees with larger diameters were more susceptible to blow down during high wind events. Damage to the standing trees is seen most in the mid-sized trees. The smaller trees are protected by the larger trees and less affected by blown down trees. Considering these trends, the ORWRP bottomland forest could drastically change the structure and composition of the existing forest in the future(Larson and Waldron, 2000).

Flooding appears to be the most influential environmental factor affecting tree species in a bottomland hardwood forest. Damage to trees increases with increasing soil saturation, water depth and inundation, but timing is critical. During dormancy tree species are less sensitive to inundation than during the growing season (Dudek et al., 1996). As disturbance and recovery are monitored in the bottomland hardwood forest two species can act as indicator or predictor species for the evolution of the riparian ecosystem. In a comparison study the eastern cottonwood (*Populus deltoides* Marsh) and the black walnut (*Juglans nigra* L.) illustrated different reactions to flooding frequency and duration. The eastern cottonwood, a flood-tolerant species, did not show significant effects with varying water levels where as the clack calnut, a flood-intolerant species, was found to be affected by the increased inundation (Dudek et al., 1998).

Different types of plants show different abilities to cope with saturated soils. To make distinctions between plants the United States Fish and Wildlife Service developed a classification system to determine the status of plants within a wetland system. Plants that occur in wetlands naturally and are most adapted to anaerobic conditions are considered to be obligate (OBL). Plants that occur in non-wetland conditions and cannot tolerate anaerobic conditions are considered to be upland (UPL). Other plant types will range between these two categories in order of decreasing tolerance of anaerobic conditions, from facultative wetland (FACW), facultative (FAC) and facultative upland (FACU). A plus sign (+) can be added to indicate more tolerance of a wet environment and a minus sign (-) can indicate less tolerance a wet environment (Reed, 1988).

The vegetation survey completed in the fall of 2001 was designed to determine the canopy species present and the characteristics of the tree species in the bottomland hardwood forest at the ORWRP. Comparisons can be made to past studies and to possible studies in the future to observe the effects of the restoration efforts.

Methods

The bottomland hardwood forest at the ORWRP is approximately 25m x 700m in the narrowest regions and 90m x 700 m in the widest regions and the forest immediately borders the Olentangy River. The levee that runs along the rivers edge is approximately three meters high and 250 meters long (Cochran and Bouchard, 2000). The point quarter method was used to sample the forest in a random format. A random format is preferable to a systematic format for most vegetation surveys because fewer quadrants are necessary to gain statistically significant results (Laferriere, 1987). The point quarter method was also chosen because it is simple, quick and useful in sampling communities in which individual plants are widely spaced and the dominant plants are large shrubs or trees (Smith, 1980). This method also provides for comparison to previous studies.

Transects were marked at East 60 degrees of North to the river. The first transect began 12 m, a random number between one and twenty, from the bridge at the western edge of the forest. The distance between each transect was 100 meters. A total of five transects were taken. Transects were marked from the bike path that runs adjacent to the forest to the river edge. Once the tree line was located along a transect a sample point was then determined by a random number measuring between one and three meters into the forest. Sampling points were made every ten meters there after. At each sample point along the transect species identification, circumference of the tree at breast height, distance in meters to the nearest tree and degree angle were recorded. To ensure that only canopy trees were sampled trees with a circumference at breast height of 40 centimeters or larger were sampled. Circumference was measured in the field due to the tools available, but later converted to diameter at breast height, DBH, using the equation:

(1)

where r = radius. Elevation was determined using an elevation map of the ORWRP for each tree sampled. In the study three trees were duplicated due to no other tree being closer within the sampling quadrant. There were six quadrants that did not have a tree with a circumference of 40 cm or larger, and they occurred either in the first sample point or in the last sample point of a transect.

Results and Discussion

There were sixteen different species recorded from the point quarter method at the bottomland hardwood forest (Table 1). Twelve of those species were recorded in a similar vegetation study at the same location in 1992 (Mitsch, 1993): green ash (*Fraxinus pennsylvanica*), northern catalpa (*Catalpa speciosa*), red mulberry (*Morus rubra*) and eastern hornbeam (*Ostrya virginiana*) were the new species recorded in the year 2001, and all four species have different wetland indicator status (Table 2). A study done in 1998 (Bouchard and Mitsch, 1999) recorded fourteen of the same species, only White Mulberry (*Morus alba*) and Eastern Hornbeam were not listed. There was an abundance of honeysuckle (*Lonicera maackii*) and papaw (*Asimina triloba*) but those tree species did not have a 40 cm or larger circumference so they were not recorded. Honeysuckle and papaw are common associates of box elder (*Acer negundo*), which was found to have the highest importance value (Table 6) and relative density (Table 2) (Tiner, 1988).

There is high diversity among the five transects, ranging from eight to ten species per transect (Table 2). Only two species were found in all five transects, american elm (*Ulmus americana*) and box elder. Importance values distinctly illustrated three top species; box elder 63.54, Ohio buckeye (*Aesculus glabra*) 54.26 and eastern cottonwood (*Populus deltoides*) 53.31 (Table 6). The species with the highest relative density for the entire bottomland forest are box elder at 19%, Ohio buckeye at 18% and eastern cottonwood at 14% (Table 2). Similar findings were found in the 1992 study (Mitsch, 1993), where the top three species for importance value and relative density were box elder at 86.16 and 36.7%, Ohio buckeye at 59.72 and 29.36% and eastern cottonwood at 49.19 and 5.5%. In the 1998 study (Bouchard and Mitsch, 1999) the number one species for relative density was box elder at 23%, then papaw at 16% followed by Ohio buckeye at 15%.

Table 3 shows that 49% of the trees sampled had a DBH between 10-19cm, and 70% of the trees sampled had a DBH between 10-29cm. According to Everham and Brokaw (1996) larger trees are most susceptible to blow down. Therefore 30% of the trees recorded are larger than 29 cm and have a higher risk of blow down. Of the 30%, twenty have wetland status and fourteen do not. All seven trees 70cm and larger are of wetland status and are either eastern sycamore (*Platanus occidentalis*) or eastern cottonwood. Eastern cottonwood is found in eight different size categories, the most diverse of all the species recorded. Size can be associated with age. One affect of periodic disturbances in mixed hardwood stands is an irregular distribution of age (Lorimer and Frelich, 1994). Therefore future inundation of soils may alter the species diversity as well as the age distribution of this bottomland hardwood forest.

The bottomland forest at ORWRP does not show strong tendencies toward wetland status. Exactly 50% of the trees sampled fall into the wetland status categories FACW to FAC and 50% fall into the FAC- to UPL categories (Table 4). According to Mitsch (1993) no wetlands were found at the ORWRP site where the experimental wetlands were constructed in 1992. There are, however, about 2 ha of jurisdictional wetland areas in the bottomland forest.

A 2000 study (Marshall, 2001) found similar results. Elevation of the bottomland surface appears to be relatively uniform and trees of both wetland categories are found at all four elevations (Table 4). Red mulberry (*Morus rubra*), northern hackberry (*Celtis occidentalis*) and Ohio buckeye, intolerant wetland species, found at a low elevation, four trees in this study, would be at risk during increased water levels (Dudek et al., 1986, 1998).

The mean distance for tree species sampled per transect

Table 1. Canopy tree species identified in the bottomland hardwood forest at the ORWRP in the fall of 2001. Abbreviations are provided to simplify subsequent tables.

species	common name	abreviation
Fraxinus pennsylvanica	green ash	GA
Acer Saccharinum	silver maple	SM
Ulmus americana	american elm	AE
Platanus occidentalis	eastern sycamore	SYC
Acer negundo	box elder	BE
Populus deltoides	eastern cottonwood	CW
Catalpa speciosa	northern catalpa	NC
Ulmus rubra	red (Slippery) elm	RE
Aesculus glabra	Ohio buckeye	OB
Prunus serotina	black cherry	BC
Juglans nigra	black walnut	BW
Celtis occidentalis	northern hackberry	HB
Morus rubra	red mulberry	RM
Morus alba	white mulberry	WM
Ostrya virginiana	eastern hornbeam	EH

Table 2. Relative density (%) of each tree species found in each of the five transects. Wetland indicator status (Reed, 1988), total relative density and total species per transect are provided for the bottomland hardwood forest at the ORWRP for the fall of 2001. Numbers in parenthesis are the number of sample points in each transect.

Indicator Status	FACW	FACW	FACW-	FACW-	FAC+	FAC	FAC	FAC	FACU+	FACU	FACU	FACU	FACU	FACU	FACU-	UPL	Total Species
Species	GA	SM	AE	SYC	BE	CW	NC	RE	OB	BC	BW	HB	RM	WM	EH	OO	
Transect#1 (3)			9	9	9	23		9		9		18	9				8
Transect#2 (5)		5	5	10	20	15			20			10	15				8
Transect#3 (4)	6		6		31				31		19			6			6
Transect#4 (7)			4		4	24	4		20	4	20	16			4		9
Transect#5 (11)		2	12	5	26	10			17		2	7	12			7	10
Relative Density	1	2	8	4	19	14	1	1	18	2	8	9	8	1	1	3	16

Table 3. Diameter at breast height, DBH, in centimeters is recorded for each tree species identified at the ORWRP bottomland forest for the fall of 2001.

Species	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	120-129
GA	1											
SM	1	1										
AE	5	2		2								
SYC		1				2			1		1	
BE	11	5	3	3								
CW	7	1	2	1			2		1	1		1
NC	1											
RE		1										
OB	13	3	2	2	1							
BC	1	1										
BW	7	1				1						
HB	5	3	2			1						
RM	2	5	2									
WM	1											
EH	1											
OO			1		1	1						
TOTAL	56	24	12	8	2	5	2	0	2	1	1	1

Table 4. Wetland status determination for total trees sampled at the ORWRP bottomland hardwood forest for fall of 2001. Elevation at tree location is given to show the distribution of trees sampled in the survey. Categories of elevation between 725-728 feet contain a variety of tree status.

	FACW to FAC	FAC- to UPL
Tree Totals for Wetland Status	57	57

Elevation at Tree Location	Feet Above MSL	% of trees	# of trees	Number of FACW to FAC Trees
	Above 728 ft.	62	71	33
	727-728 ft	28	32	17
	726-727ft.	6	7	4
	725-726 ft.	4	4	3
	Below 725 ft.	0	0	0

Table 5. Mean distance for tree species sampled per transect (Total distance/number of distances; Smith, 1980). Location of each tree in the point quarter method is measured in meters from the quadrant sample point. All samples were taken from the bottomland hardwood forest at the ORWRP in the fall of 2001.

Transect	No. of trees sampled	Mean Distance, m
1	11	5.43
2	20	5.15
3	16	5.34
4	25	5.62
5	42	3.64
Total	114	4.75

Table 6. The Importance Value has been determined for each tree species. For description of calculations refer to Mitsch, 1993.

Tree Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value
BE	19.3	25.73	18.52	63.54
OB	18.42	23.5	12.34	54.26
CW	14.03	25.69	13.58	53.31
HB	9.65	6.78	11.11	27.54
RM	7.89	4.34	8.64	20.88
AE	7.89	4.12	8.64	20.66
BW	7.89	4.1	8.64	20.64
SYC	4.39	4.12	4.94	13.44
OO	2.63	1.04	2.47	6.15
BC	1.75	0.19	2.47	4.41
SM	1.75	0.18	2.47	4.4
RE	0.88	0.06	1.23	2.17
GA	0.88	0.04	1.23	2.15
NC	0.88	0.04	1.23	2.15
EH	0.88	0.03	1.23	2.14
WM	0.88	0.03	1.23	2.14

appear to be consistent (Table 5). Only in transect five is there a significantly smaller mean distance. Overall, trees are approximately 4.75m from each sample point (Table 5). Future comparisons may show effects from the restoration efforts.

With continued water inundation into the bottomland hardwood forest there should be a shift in the vegetation towards wetland status. Restoring the connection to the river should also increase the productivity of the bottomland hardwood forest.

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